Consultative
Committee for
Space Data Systems

RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

STANDARD FORMATTED DATA UNITS - - STRUCTURE AND CONSTRUCTION RULES

CCSDS 620.0-B-1

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This Recommendation reflects the consensus technical agreement of the following member Agencies of the Consultative Committee for Space Data Systems (CCSDS):

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o Centre National D' Etudes Spatiales (CNES)/France.
o Deutsche Forschungs-u. Versuchsanstalt fuer Luft und Raumfahrt e.V. (DFVLR)/West Germany.
o European Space Agency (ESA)/Europe.
o Indian Space Research Organization (ISRO)/India.
o Instituto de Pesquisas Espaciais (INPE)/Brazil.
o National Aeronautics and Space Administration (NASA)/USA.
o National Space Development Agency of Japan (NASDA)/Japan.

The following observer Agency also concurs with this Recommendation:

o Department of Communications, Communications Research Centre (DOC-CRC)/Canada.

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STATEMENT OF INTENT

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o Whenever an Agency establishes a CCSDS-related Standard, this Standard will be in accord with the relevant Recommendation. Establishing such a Standard does not preclude other provisions which an Agency may develop.

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-- The Standard itself.

-- The anticipated date of initial operational capability.

-- The anticipated duration of operational service.

o Specific service arrangements shall be made via memoranda of agreement. Neither this Recommendation nor any ensuing Standard is a substitute for a memorandum of agreement.

No later than five years from the date of its issuance, this Recommendation will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or, (3) be retired or cancelled.

FOREWORD

This document is a technical Recommendation for the standardization of the structure and construction rules of Standard Formatted Data Units (SFDU) for the interchange of digital space-related data in an open data system and has been prepared by the Consultative Committee for Space Data Systems (CCSDS). Other aspects of the SFDU concept are described in documents listed in the Reference section.

This Recommendation defines an SFDU structure that will handle problems of digital data interchange and construction rules that will limit the SFDUs to a practical set that can exist in an open data system environment. It allows implementing organizations within each Agency to proceed coherently with the development of compatibly derived Standards for space data systems and widely dispersed data users that are within their cognizance. Derived Agency Standards may implement only a subset of the optional features allowed by the Recommendation and may incorporate features not addressed by the Recommendation.

Through the process of normal evolution, it is expected that expansion, deletion, or modification to this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures which are defined in Reference [1].

Questions relative to the contents or status of this document should be addressed to the CCSDS Secretariat

DOCUMENT CONTROL

Document	Title	Date	Status/ Remarks
CCSDS 620.0-B-1	Recommendation for Space Data System Standards: Standard Formatted Data Units--Structure and Construction Rules, Issue 1	February 1988	Original Issue

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REFERENCES

[1] "Procedures Manual for the Consultative Committee for Space Data Systems, "Consultative Committee for Space Data Systems, Issue 1, August 1985 or later issue.

[2] "Report Concerning Space Data Systems Standards: Space Data Systems Operations with Standard Formatted Data Units: Systems and Implementation Aspects," CCSDS 610.0-G-5, Green Book, Issue 5, February 1987 or later issue.

The latest issues of CCSDS documents may be obtained from the CCSDS Secretariat at the address indicated on page i.

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this document is to establish a common Recommendation for the implementation of a standard data structure for the purpose of interchanging data in a more uniform and automated fashion within and among Agencies participating in the Consultative Committee for Space Data Systems (CCSDS).

This Recommendation defines a Standard Formatted Data Unit (SFDU) structure, a set of construction rules, and the aggregated structures that can be built. Only the conceptual aspects of data interchange are addressed in this Recommendation.

The operating principles and procedures for the CCSDS are defined in Reference [1]. The general SFDU data interchange concept and the role of the various elements are described in Reference [2].

1.2 APPLICABILITY

This Recommendation serves as a guideline for the development of compatible internal Agency standards in the field of digital data interchange. This Recommendation applies to the structures of digital data as interchanged between users associated with projects, archives, and real-time operations, including command generation and receipt, as well as data routing. This Recommendation is not retroactive, nor does it commit any Agency to implement the recommended SFDU concept at any future time. Nevertheless, all CCSDS Agencies accept the principle that all future implementations of digital interchange with open data systems supported by the Agencies will be based on this Recommendation, as long as it remains in force.

To be compatible with the CCSDS SFDU concept at the present, an Agency must use one of the structures that can be defined by this Recommendation and must provide the necessary information so that the data can be retrieved and processed. The mechanisms for providing this information may be accomplished in conventional ways until standards can be recommended by CCSDS.

The specifications in this document are to be invoked through the normal standards program of each member Agency and are applicable to those missions and services for which cross-support based on the need for open system data interchange is anticipated.

1.3 OCTET AND BIT NUMBERING CONVENTION AND NOMENCLATURE

In this document, the following convention is used to identify each octet (8-bit field) in an N-Octet field:

> The first octet in the field (to be transmitted) shall be drawn in the most left justified position and is defined to be "Octet 0". The following octet is defined as "Octet 1" and so on up through "Octet N-1". When the field is used to express a numerical value, the Most Significant Octet (MSO), shall be the first octet of the field, i.e.,"Octet 0". The

of any octet shall be the first bit transmitted and it shall be drawn in the most left justified position and designated as "Bit 0". The transmission sequence shall go from MSB through the Least Significant Bit (LSB), which is "Bit 7".

1.4 RECOMMENDED APPROACH TO READING THE DOCUMENT

A proper understanding of this Recommendation requires familiarity with the SFDU concept and the specific meanings of the terminology used in this document. A complete summary of the acronyms and the terminology used internal to this document is presented in Annex A. It is recommended that this be read prior to reading the main body of the document.

* "Telemetry Channel Coding", Recommendation CCSDS 101.0-B-2, Issue 2, Blue Book, Consultative Committee for Space Data Systems, January 1987 or later issue.

2 SFDU STRUCTURE AND FIELD SPECIFICATIONS

The basic SFDU structure is called Type-Length-Value or TLV encoding. This structure, comprising a TYPE, a LENGTH, and a VALUE field, is referred to as a TYPE-LENGTH-VALUE Object (TLVO) and is the fundamental structural element used to build the recommended SFDUs.

In this approach, data exchanged between open (independent) data systems are tagged with a TYPE identifier and a LENGTH indication, as shown in Figure 2-1. In SFDU usage, the specification of the TYPE (T) and LENGTH (L) field combination (TL field or label) is identified by an embedded version identifier at a fixed location in the TYPE field. A restricted character set of ASCII, denoted by RA, is the set of characters, allowed in the TYPE field. This set, totalling 36 characters, is comprised of the numeric characters 0-9 and the upper case Roman letters. Two versions are recommended and both have fixed lengths for both the TYPE and LENGTH fields. The TYPE field contains an identifier (ID) of the data descriptive record (DDR). The DDR contains the definition of the format and the parsing rules of the VALUE field. The TYPE field contains a global identifier referred to as ADI, which is comprised of the Control Authority ID\and the DDR ID. The LENGTH field is interpreted as a numeric value that represents the length of the VALUE field in units of octets. While the TL field structure and representation are highly restricted by the Recommendation to only two versions, the VALUE field can be quite varied in terms of its internal structure and representation. A more detailed breakdown of the three fields is shown in Figure 2-2.

The conventions of Section 1.3 apply only to the TYPE and LENGTH fields, not to the VALUE field.

2.1 TYPE FIELD

2.1.1 CONTROL AUTHORITY ID

The first sub-field (Octet 0-3) of the TYPE field is the Control Authority (CA) ID, which shows the organizational entity that has the registration responsibility for the DDR. The registration process establishes a method by which each specific data object specification/definition (i.e., DDR) can be uniquely referenced and is described in Reference [2]. The only allowed instances of this sub-field are characters of the RA set.

2.1.2 VERSION ID

The second sub-field (Octet 4) identifies the structure (given in Figure 2.2) and coding of the label. There are currently two recommended versions. Version 1 (ID = RA character 1) defines the LENGTH field as an RA numeric character string. Version 2 (ID = RA character 2) defines the LENGTH field as unsigned binary.

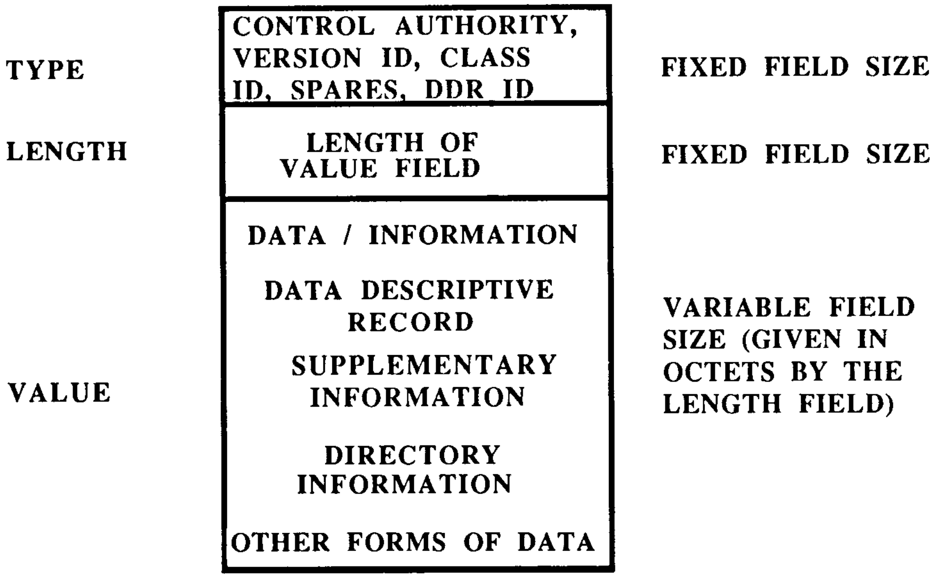

Figure 2-1: TLV Encoding Structure

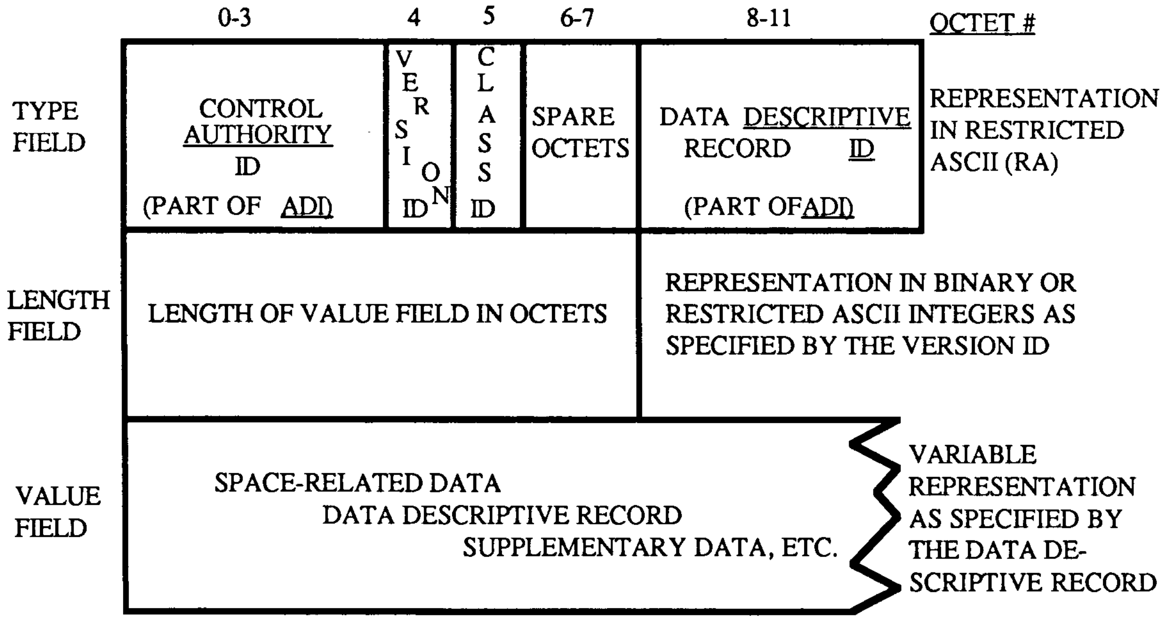
0-3
4
5
6-7
8-11
OCTET #
TYPE FIELD
CONTROL AUTHORITY ID (PART OF ADI)
VERSION ID
CLASS ID
SPARE OCTETS
DATA DESCRIPTIVE RECORD ID (PART OF ADI)
REPRESENTATION IN RESTRICTED ASCII (RA)
LENGTH FIELD
LENGTH OF VALUE FIELD IN OCTETS
REPRESENTATION IN BINARY OR RESTRICTED ASCII INTEGERS AS SPECIFIED BY THE VERSION ID
VALUE FIELD
SPACE-RELATED DATA
DATA DESCRIPTIVE RECORD
SUPPLEMENTARY DATA, ETC.
VARIABLE REPRESENTATION AS SPECIFIED BY THE DATA DESCRIPTIVE RECORD

Figure 2-2. Basic Structure of the TLV Object

2.1.3 CLASS ID

The third sub-field (Octet 5) is used to classify the VALUE field for the purpose of SFDU interpretation. The recommended values for the class ID are shown in Table 2.1.

Table 2.1 Class ID Instances

Class ID	Classification of VALUE Field
D	Data Descriptive Record
I	Data
S	Supplementary Information
Z	Comprised of one or more TLV Objects and/or SFDUs.

2.1.4 SPARE OCTETS

The fourth sub-field (Octets 6-7) is set to RA numeric characters 00 for Versions 1 and 2.

2.1.5 DDR ID

The last sub-field of the TYPE field (Octets 8-11) is used along with the CA ID to identify the DDR. The DDR ID sub-field consists of four RA characters.

2.2 LENGTH FIELD

This field is used to specify the length of the VALUE field in octets and is represented in either the numeric character subset of RA (Version ID = 1) or binary (Version ID = 2). The eight octets specified for this field provide for lengths of 1 x 10^8 octets (Version ID = 1) and 1.8 x 10^{19} octets (Version ID = 2). This field should always be completely filled, with leading zeros as necessary.

2.3 VALUE FIELD

This field contains various forms of data and information as shown in Figures 2.1 and 2.2. This variable length field can be in any desired code or representation that can be expressed with a DDR.

3 CONSTRUCTION RULES

The SFDU defined in this Recommendation is an aggregation of two or more TLV Objects. The first TLV Object shall always have the following unique TYPE field instance:

CA ID = CCSD; Version ID = 1 or 2; Class ID = Z; DDR ID = 0001

and shall be denoted hereinafter as a T_Z TYPE field. This TLV Object indicates that the SFDU follows the recommended construction rules given below.

3.1 RULE 1

The SFDU is composed of: (i) a T_Z TYPE field, (ii) a LENGTH field, and (iii) a VALUE field comprised either of a sequence of one or more TLV Objects with Class ID not equal to Z, denoted by T_{nz}, or of a sequence of SFDUs, or of a sequence of T_{nz} Objects and SFDUs in any order.

This rule is expressed formally in Annex B and is illustrated in Figure 3-1.

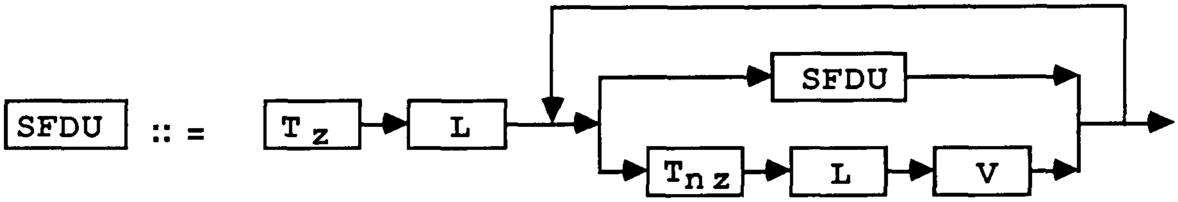

Figure 3-1. Diagrammatic Definition of the Recommended SFDU. T_Z is a Class Z TYPE field. T_{nz} is a Class non-Z TYPE field; V is a VALUE field for a T_{nz} TYPE field and L is a LENGTH field.

3.2 RULE 2

If an SFDU contains a TLV Object with Class ID = D [denoted by TLVO(D)], this TLVO(D) must precede any TLV Object that requires this TLVO(D) for its interpretation.

3.3 RULE 3

The portion of the VALUE field of each TLV Object with Class ID = D which is used to specify the rules for an interpretation of a data object must be expressed in only one DDL. These interpretation rules for the same data object may also be expressed in other Class ID = D TLVOs with the same restrictions.

ANNEX A:

STANDARD FORMATTED DATA UNIT ACRONYMS AND TERMINOLOGY

(THIS ANNEX IS A PART OF THE RECOMMENDATION)

Purpose:

This annex defines key acronyms and terms which are used throughout this Recommendation to describe the concepts and elements of the Standard Formatted Data Unit.

A-1 ACRONYMS AND TERMINOLOGY

A-1.1 ACRONYMS

ADI:	Authority and Data Descriptive Record Identifier
ASCII:	American Standard Code for Information Interchange
CA:	Control Authority
CCSDS:	Consultative Committee for Space Data Systems
DD	Data Descriptive Language
DDR:	Data Descriptive Record
ID:	Identifier
ISO:	International Organization for Standardization
RA:	Restricted ASCII
SFDU:	Standard Formatted Data Unit
TLV	Type-Length-Value
TLVO:	TYPE-LENGTH-VALUE Object

A-1.2 TERMINOLOGY

ASCII: a seven-bit code also known as the USA Standard Code for Information Interchange (USASCII). ASCII is commonly embedded in an eight-bit field in which the highest order bit (written as the leftmost) is either used as a parity bit or set equal to zero. The eight-bit code with the highest order bit set equal to zero will be used in this Recommendation.

CODE: a correspondence between a symbol or character of a written language and a number of digits of a number system.

CONCEPTUAL STRUCTURE: the organization of a data object/unit used for analytical or deductive reasoning about the information it carries. A conceptual data structure may have several formats, e.g., on different media.

CONTROL AUTHORITY (CA): a collection of CCSDS member Agency organizations (Control Authority Offices) under the auspices of the CCSDS Secretariat, responsible for registering, archiving, and distributing the data descriptive record (DDR) upon request . Each Agency organization has agreed to meet the minimum recommendations of CCSDS on CA operations.

DATA DESCRIPTIVE LANGUAGE (DDL): a formal notation for specifying the conceptual structure of data objects.

DATA DESCRIPTIVE RECORD (DDR): a set of DDL statements that convey the information necessary to parse the VALUE field of a specific TLV Object.

DATA ELEMENT: the smallest named item or items of data for a given application.

DATA OBJECT: a collection of data elements that are aggregated for or by a specific application.

DATA SYSTEM: a system of an enterprise with the goal to provide services which satisfy the information needs of the enterprise. Major operating facilities of the data system are: physical storage, data management, data retrieval, and data manipulation facilities.

DATA UNIT: an aggregation of data objects which forms a single data interchange entity.

FIELD: an abstract component of a data unit that is assigned a length and a representation. The instance of a field is the field value. Fields may be divided into sub-fields.

FORMAT: the assignment of each of the data elements of a data object to a field or sub-field and to a specific location or address on a given physical medium or in a device.

GLOBAL: pertaining to the CCSDS sphere of influence.

INSTANCE: a data object, or a set of data objects, that exhibits the distinguishing characteristics of its class. An instance of an SFDU is one of a set of values for the data unit which is presented in a specified format. The term *instance* is used where an individual data unit must be distinguished from its format.

INTERPRET: to explain or present in understandable terms. SFDU interpretation is the process of recognizing the format of a data unit, identifying its component parts, and extracting and processing the information it carries.

LABEL FIELD(S): the combination of the TYPE and LENGTH fields of a TLV Object.

LOGICAL REPRESENTATION: the assignment of data type and data structure attributes to the entities specified to a machine (computer) for a given application. Examples of data type attributes are real, integer, double precision, complex, logical (boolean), and character. Examples of structural attributes are scalar, array, fields, and logical records.

OCTET: a data object consisting of eight bits.

OPEN DATA SYSTEM: a data system which offers its service to customers outside the enterprise. These outside customers need to know how to operate a service access port. Thus they must be able to: (a) communicate with the system, (b) request data services (c) accept data products, and (d) elaborate the structure of these products according to standard protocols and structuring rules defined in the public domain.

RESTRICTED ASCII (RA) CHARACTER SET: the subset of the ASCII character set consisting of the numeric characters, 0-9, and the upper case letters, A-Z, of the Roman alphabet.

SERVICE: work performed for the benefit of others. Numerous services are involved in the operation of open data systems, including: data collection, conversion, and storage; communication services; archive services such as catalog queries and data distribution; and control authority services such as registration and distribution of DDRs.

STANDARD FORMATTED DATA UNIT (SFDU): SFDUs are data units that conform to CCSDS recommendations for structure, construction rules, and field specification definition.

TYPE-LENGTH-VALUE OBJECT (TLVO): a fundamental structural data object that is used to build SFDUs. This object consists of a TYPE field, followed by a LENGTH field, and this is followed by a VALUE field. The flexibility of the VALUE field permits it, under certain conditions, to contain complete TLV Objects and/or complete SFDUs as part of its structure.

ANNEX B :

FORMAL LANGUAGE DESCRIPTION

(THIS ANNEX IS PART OF THE RECOMMENDATION)

Purpose:

This Annex provides the formal description of the construction of the specific SFDU that is recommended.

B-1 FORMAL LANGUAGE DESCRIPTION

The Backus-Naur Form* is the formal language used to express the recommended SFDU. This language is usually known by the acronym, BNF, and is the best known example of a metalanguage, i.e., one that syntactically describes a programming language. A metalinguistic variable is one whose values are strings of symbols chosen from among the the symbols permitted in the given language. In BNF metalinguistic variables are enclosed by brackets, < >, for clarity and for distinguishing them from the symbols of the language itself.

The symbol ::= is used to indicate metalinguistic equivalence. The symbols [ ]$^+$ and < >$^+$ are used to indicate that a sequence of arbitrary length is to be constructed from the symbols that are allowed. If the $^+$ signs are replaced by the letter "n", the sequence is of length exactly "n". A vertical bar "|" is used to indicate that a choice is to be made among the items so indicated. With these definitions we can now describe this SFDU construction formally .

SFDUs have a Type-Length-Value or TLV encoding with the following syntax:

<SFDU> ::= <T$_z$><L>[<SFDU>|<T$_{nz}$><L><V>]$^+$

<T$_z$> ::= CCSD<VERSION_ID>Z000001

<T$_{nz}$> ::= <CA_ID><VERSION_ID><CLASS_ID_NOT_Z>00<DDR_ID>

<L> ::= <A_DIGIT>^{8}|<B_DIGIT>^{64} {Use <A_DIGIT> for <VERSION_ID> ::= 1; use <B_DIGIT> for <VERSION_ID> ::= 2}

<V> ::= {Variable field with space-related data, DDR, supplementary data, etc. in any desired code or representation as specified by the DDR}

<CA_ID> ::= <RA><RA><RA><RA>
<VERSION_ID> ::= 1|2
<CLASS_ID_NOT_Z> ::= D|I|S
<DDR_ID> ::= <RA><RA><RA><RA>
<RA> ::= <A_DIGIT>|<LETTER>
<A-DIGIT> ::= 0|1|2|3|4|5|6|7|8|9
<B_DIGIT> ::= 0|1
<LETTER> ::= A|B|C|D|E|F|G|H|I|J|K|L|M|N|O|P|Q|R|S|T|U|V|W|X|Y|Z

* *Encyclopedia of Computer Science and Engineering*, Second Edition, A. Ralston, Editor, Van Nostrand Reinhold Company, Inc., New York, 1983.

Samment, Jean E., *Programming Languages : History and Fundamentals*, Prentice-Hall, Englewood Cliffs, NJ, 1969.

ANNEX C:

RESTRICTED ASCII CODE

(THIS ANNEX IS PART OF THE RECOMMENDATION)

Purpose:

This Annex provides the eight-bit code for the symbols that comprise the Restricted ASCII character set used in the TYPE field and one version of the LENGTH field in this Recommendation.

C-1 RESTRICTED ASCII CODE

A code is a correspondence between a symbol and a number of digits of a number system. The American Standard Code for Information Interchange (ASCII) is a seven-bit code also known as the USA Standard Code for Information Interchange (USASCII). It was issued by the American National Standards Committee for Computers and Information Processing (ANSC-X3). The latest updated American National Standards Institute ANSC-X3 standard for this is ANSI X3.4-1977. (See *Encyclopedia of Computer Science and Engineering* , Second Edition, A. Ralston, Editor, Van Nostrand Reinhold Company, Inc., New York, 1983 for more details.) This code has been incorporated into the ISO code of the same nature (ISO 646-1983) which includes other symbols and alphabets. Since the ISO code is an eight-bit code, the ASCII code is embedded in an eight-bit field in which the higher order bit is set to zero. Thus the ASCII code is also referred to as ISOASCII. Consequently the Restricted ASCII set defined here and used in this Recommendation is a subset of ISOASCII and the primary reference should be ISO 646-1983.

The Restricted ASCII or RA code is given in Table C.1 for all the RA symbols (characters) in the binary, decimal, and hexadecimal number systems.

Table C.1 Restricted ASCII Code

Symbol	Binary Value	Decimal Value	Hexadecimal Value
0	0011|0000	48	3|0
1	0011|0001	49	3|1
2	0011|0010	50	3|2
3	0011|0011	51	3|3
4	0011|0100	52	3|4
5	0011|0101	53	3|5
6	0011|0110	54	3|6
7	0011|0111	55	3|7
8	0011|1000	56	3|8
9	0011|1001	57	3|9
A	0100|0001	65	4|1
B	0100|0010	66	4|2
C	0100|0011	67	4|3
D	0100|0100	68	4|4
E	0100|0101	69	4|5
F	0100|0110	70	4|6
G	0100|0111	71	4|7
H	0100|1000	72	4|8
I	0100|1001	73	4|9
J	0100|1010	74	4|A
K	0100|1011	75	4|B
L	0100|1100	76	4|C
M	0100|1101	77	4|D
N	0100|1110	78	4|E
O	0100|1111	79	4|F
P	0101|0000	80	5|0

Table C.1: Cont'd

Symbol	Binary Value	Decimal Value	Hexadecimal Value
Q	0101|0001	81	5|1
R	0101|0010	82	5|2
S	0101|0011	83	5|3
T	0101|0100	84	5|4
U	0101|0101	85	5|5
V	0101|0110	86	5|6
W	0101|0111	87	5|7
X	0101|1000	88	5|8
Y	0101|1001	89	5|9
Z	0101|1010	90	5|A

The vertical bar, |, has been used to separate the first four bits (bits 0-3) from the second four bits (bits 4-7). The bit positions are as given in Section 1.3 on page 1-2. The hexadecimal digits are also separated by the |. The decimal value cannot be segmented in this manner, but the decimal values are equivalent to the binary and hexadecimal values.